



THIS SHEET HAS BEEN
REPLACED

Wire saw, fitting station, maintenance and running-in station for a wire-guiding-roller unit of the wire saw, and method of exchanging the wire-guiding-roller unit

5 The invention relates to a wire saw for cutting
wafers from a workpiece, in particular a wire saw for
producing semiconductor wafers. The wire saw comprises a
saw head in which at least two wire-guiding rollers are
mounted rotatably in each case between a moveable bearing
and a fixed bearing, adjacent wire-guiding rollers,
10 together with a wire wound around them, forming a wire
frame. In conjunction with a sawing suspension, the wire
frame acts as a cutting tool. A sawing suspension may be
dispensed with if use is made of a sawing wire with
bonded cutting particles. The invention also relates to
15 a fitting station and to a maintenance and running-in
station for a wire-guiding-roller unit and to a method of
exchanging the wire-guiding-roller unit.

A wire saw of the generic type mentioned with a
saw head in which the wire-guiding rollers are mounted in
20 each case between a moveable bearing and a fixed bearing
in a saw head, is described, for example, in
EP-733 429 A1. This wire saw can be used to cut a multi-
plicity of semiconductor wafers of a specific thickness
from a piece of crystal during a cutting operation. The
25 thickness of the semiconductor wafers is determined by
the distance between the windings of the sawing wire in
the wire frame. This distance, in turn, is essentially
predetermined by grooves which are located in the cover-
ing of the wire-guiding rollers and in which the wire
30 runs. The wire saw also has a heating/cooling system for
controlling the temperature of the wire-guiding rollers
and of the moveable bearing and fixed bearing assigned
thereto. In this way, undesired sawing-wire displacement
as a result of heat expansion of machine parts is to be
35 kept to a minimum.

It is necessary to change the covering of the
wire-guiding roller or the wire-guiding roller itself, in
particular, when the cutting result deteriorates as a

result of the covering being worn or if it is intended that the thickness of wafers which are to be cut subsequently should be changed to a new value. Deterioration of the cutting result may also indicate damaged bearings.

5 If the covering or the bearings are changed, it is necessary for the wire-cutting roller or the bearings to be removed from the saw head. Up until now, this has involved high outlay and has resulted in the wire saw being at a standstill for long periods of time. Once a
10 new wire-guiding roller or new or repaired bearings have been introduced, the wire saw then still requires a certain period of time in order to be run in and brought to operating temperature before stable operation is possible. After this, a test workpiece then usually has
15 to be sawn before the actual production of wafers can be continued.

 The present invention achieves the object of shortening the period during which the wire saw has to be at a standstill in order that a wire-guiding roller or
20 bearings can be changed, and of simplifying the procedure for changing a covering.

 The invention relates to a wire saw of the generic type mentioned which is defined in that each wire-guiding roller and the moveable bearing and fixed
25 bearing assigned to it form a wire-guiding-roller unit, which can only be removed from the saw heads as an entire unit.

 The wire-guiding roller and the bearing shafts also form a rigid unit, which is balanced as such and of
30 which the bearing seats and covering mount can be produced in one operation.

 With the known designs, in which the bearing shafts have to be separated from the wire-guiding rollers in order for the latter to be moved, the coolant located
35 in the bearing shafts and the wire-guiding roller (insofar as internal cooling is provided for) flows into the sawing area and changes the composition of the sawing suspension, with the result that the latter may even become unusable. This cannot take place in the case of

the proposed design since the wire-guiding roller and bearing shafts are removed as a unit.

5 The combination of the wire-guiding roller and moveable bearing and fixed bearing to form a wire-guiding-roller unit not only permits swift removal of the wire-guiding roller and of the bearings, but also makes it possible for the wire-guiding roller which has been removed to be provided with a new covering in a fitting station, it being possible, following this and the
10 reinstallation of the wire-guiding-roller unit in the wire saw, to dispense with the running-in operation of the wire saw for the purpose of reaching the necessary operating temperature.

15 With the wire-guiding-roller/bearing design of the known type, the wire-guiding rollers are screwed between the fixed-bearing shaft and moveable-bearing shaft such that the drive forces are transmitted, but the bearing shafts and wire-guiding roller do not form a single-piece, rigid unit. The fixed-bearing and moveable-
20 bearing shafts are therefore each mounted with two bearing assemblies for stabilizing purposes.

25 The 3-part screwed arrangement of the bearing shafts and wire-guiding roller involves high outlay and results in misalignment and thus stressing in the shaft system, which in turn results in the service life of the bearings being shortened and in uncontrolled heating of the bearings. Moreover, the geometry of the wafers which are to be cut is influenced by the erratic running which occurs as a result of misalignment.

30 The present invention thus also achieves the object of avoiding misalignment, of simplifying the bearing design and of ensuring smooth running.

35 The invention also relates to a fitting station for a wire-guiding-roller unit with a wire-guiding roller, a moveable bearing and a fixed bearing, comprising

- a) supporting surfaces for supporting the wire-guiding-roller unit;
- b) retaining elements for fixing the wire-guiding-

roller unit on the supporting surfaces;

c) a heating/cooling system for controlling the temperature of the wire-guiding-roller unit; and

5 d) means for detaching a covering from the wire-guiding roller.

The period during which the wire saw is at a standstill is shortened considerably if the wire-guiding-roller unit which has been removed from the wire saw is replaced by another wire-guiding-roller unit, which has
10 already been prepared for use in a fitting station.

It is also possible for the bearings of the wire-guiding-roller unit which has been removed from the wire saw to be repaired or exchanged outside the wire saw. It is proposed for the wire-guiding-roller unit to be run in
15 in a maintenance and running-in station once the bearings have been repaired or changed. During this time, the wire saw can be used to produce wafers with a wire-guiding-roller unit which, for example, has been prepared and run in in another maintenance and running-in station. The
20 elimination of a running-in phase in the wire saw and the sawing of a test workpiece means that the period during which the wire saw is at a standstill is shortened to the time taken to exchange wire-guiding-roller units.

The invention thus also relates to a maintenance
25 and running-in station for a wire-guiding-roller unit with a wire-guiding roller, a moveable bearing and a fixed bearing, comprising

a) bearing supports for the bearings of the wire-guiding-roller unit;

30 b) a heating/cooling system for controlling the temperature of the wire-guiding-roller unit;

c) a drive for running in the wire-guiding-roller unit; and

d) a device for monitoring the running-in operation of
35 the wire-guiding-roller unit.

Lastly, the invention relates to a method of exchanging a wire-guiding-roller unit of a wire saw for cutting wafers from a workpiece. The method is defined in that the wire-guiding-roller unit, which comprises a

wire-guiding roller provided with a covering as well as a moveable bearing and a fixed bearing, is displaced axially from an operating position into a release position and is removed from the wire saw with the aid of a manipulator, and a wire-guiding-roller unit which has been temperature-controlled in advance is moved into the operating position.

The invention is explained in more detail hereinbelow with reference to figures. The figures are sectional illustrations of preferred exemplary embodiments of the invention. They disclose a wire saw with a wire-guiding-roller unit, a fitting station and a maintenance and running-in station. Only those features which aid comprehension of the invention are illustrated. In the figures:

Figure 1 shows a wire-guiding-roller unit installed in a wire-saw head;

Figure 2 shows the wire-guiding-roller unit according to Figure 1 in a release position, in which it can be lifted out of the saw head;

Figure 3 shows the wire-guiding-roller unit according to Figure 2 in a fitting station according to the invention;

Figure 4 shows the wire-guiding-roller unit according to Figure 2 in an arrangement which is suitable for the purpose of repairing or changing the bearings; and

Figure 5 shows the wire-guiding-roller unit according to Figure 2 in a maintenance and running-in station according to the invention.

The same designations are used in the figures to denote the same features.

Let us first of all refer to Figure 1. The wire-guiding roller 1 is mounted rotatably between a moveable bearing 2 and a fixed bearing 3 in a saw head 4. Preferably 2 to 4 wire-guiding rollers are accommodated in the saw head, and at least one of them is driven. The cylindrical body of the wire-guiding roller is tapered at the sides to form a bearing shaft 5. The moveable bearing

2 and the fixed bearing 3 are seated on the bearing shaft and form a wire-guiding-roller unit 6 with the wire-guiding roller 1. Located on the wire-guiding roller is a single-piece covering 7 which has guide grooves (not
5 illustrated) and is centered by a releasable ring 8 and is secured against axial displacement. The wire-guiding roller illustrated is driven by a motor 9, of which the torque is transmitted directly via a coupling. In the context of the invention, however, it is unimportant for
10 the wire-guiding roller to have its own drive. Pivot tensioners 10 are provided in order to safeguard against undesired axial displacement of the wire-guiding-roller unit, and clamping elements 11 are provided in order to fix the moveable bearing 2. These fix the wire-guiding-
15 roller unit in the saw head in an operating position. The pivot tensioners 10 and the clamping elements 11 are preferably moved hydraulically.

The temperature of the wire-guiding-roller unit is controlled with the aid of a heating/cooling system
20 12. The latter comprises supply lines 13 and 14 which are connected to channels in the interior of the wire-guiding roller and of the moveable bearing and maintain circulation of temperature-controlling medium in the wire-guiding roller and in the moveable bearing. The heating/
25 cooling system also comprises temperature-controlling segments 15 with corresponding supply lines 16 for controlling the temperature of the fixed bearing from the outside. These segments butt against the slightly conically designed lateral surface of the fixed bearing
30 and are pressed against the lateral surface by springs. A constant airstream can be routed into the region of the fixed bearing with the aid of a sealed air line 17, and constituents of the sawing suspension or of the abraded material produced during the cutting operation are thus
35 prevented from being able to penetrate into the fixed bearing.

A removal aid is provided for the purpose of removing the wire-guiding-roller unit from the wire saw. In the exemplary embodiment illustrated, this removal aid

comprises a linear carriage system 19 which is provided with a spindle drive 18 and by means of which the wire-guiding-roller unit 6 can be displaced axially into a release position. Prior to this, it is necessary for the
5 sawing wire to be removed and for the arresting action of the pivot tensioners 10 and clamping elements 11 to be eliminated. Furthermore, the supply lines 13 and 14 have to be separated from the wire-guiding-roller unit, independently closing valves being provided at the
10 separation points.

A situation in which the wire-guiding-roller unit is already located in the release position is illustrated in Figure 2. The embodiment of the wire which is shown has a coupling between the drive and the fixed bearing
15 and, upon displacement of the wire-guiding-roller unit into the release position, this coupling is automatically separated into a half 20 which remains in the saw head and a half 21 which remains connected to the wire-guiding-roller unit 6. The sealed air line 17 is likewise
20 automatically separated during the displacement of the wire-guiding-roller unit. In the release position, it is possible, with the aid of a manipulator, for the wire-guiding-roller unit to be lifted out of the saw head in the direction of the arrow and transferred, for example,
25 into a fitting station. In order to avoid longer periods during which the wire saw is at a standstill, another wire-guiding-roller unit, which has already been prepared for use, is moved into the operating position, preferably immediately after the original wire-guiding-roller unit
30 has been removed, in the reverse order to which said removal operation takes place. Of course, the possibility of the wire-guiding-roller unit which has been removed being reconditioned, for example cleaned and provided with a new covering, and then replaced in its original
35 position in the saw head should not be ruled out either. When the wire-guiding-roller unit is installed, the temperature-controlling segments 15 automatically come into contact with the lateral surface of the fixed bearing 3 (Figure 1). There is no need for any supply

lines to be connected.

The covering of the wire-guiding roller is changed in a fitting station provided for this purpose. Figure 3 illustrates a fitting station 22 with a wire-guiding-roller unit 6 accommodated therein and part of a manipulator which is suitable for moving the wire-guiding-roller unit. The manipulator expediently has tongue-like grippers 23, which enclose the wire-guiding-roller unit laterally, and a pivot spindle 24, which allows the wire-guiding-roller unit to rotate through 90°. The wire-guiding-roller unit which has been removed from the saw head is rotated through said angle and set down, or if appropriate fitted, on supporting surfaces 25 of the fitting station and fixed thereon by retaining elements 26. The fitting station 22 is provided with a heating/cooling system 27 for controlling the temperature of the wire-guiding-roller unit 6. This system comprises supply lines 29 which are connected to channels in the interior of the wire-guiding roller and of the moveable bearing and of the fixed bearing and maintain circulation of temperature-controlling medium in the wire-guiding roller and in the moveable bearing and in the fixed bearing. Furthermore, the temperature of the moveable bearing is controlled from the outside via the supply lines 28. Temperature-controlling segments 30 with corresponding supply lines 31 are provided for controlling the temperature of the fixed bearing from the outside and can be moved up to the fixed bearing by means of linear advancement elements 32. Provided in the fitting station for the purpose of facilitating the operation of changing a covering is a tool 33 which can detach the covering 7, which in the exemplary embodiment illustrated is molded onto a single-part sleeve 34, from the wire-guiding roller. The sleeve 34 is preferably produced from a CRP material (CRP = carbon-fiber-reinforced plastic). The sleeve is seated on a covering mount of the wire-guiding roller.

The heating/cooling system is used to control the temperature of the wire-guiding-roller unit in advance as

it remains in the fitting station, with the result that, once it has subsequently been installed in the wire saw, there is no need for any heating-up phase during which the wire-guiding roller has to be brought to operating temperature. All that is required in order to make the wire saw ready for operation again is to move the wire-guiding-roller unit into the operating position in the saw head, in the reverse order to which its removal operation takes place, and to provide the wire-guiding rollers with a new sawing wire.

The fitting station may be designed as a displaceable fitting carriage which, if required, is moved up to the wire saw. Another embodiment provides for the fitting station and, if appropriate, also the manipulator to be positioned on the wire saw. Finally, it is also possible for the fitting station to be designed such that it can receive more than one wire-guiding-roller unit.

If it is necessary for the bearings of the wire-guiding-roller unit to be repaired or changed, the wire-guiding-roller unit is removed from the wire saw or the fitting station as has already been described and is preferably arranged such that the bearings are freely accessible. Such an arrangement is shown in Figure 4. The wire-guiding-rolling unit 6 is located outside the wire saw on a repair bench 35 and is supported on the latter by means of supports 47. Once the necessary work has been completed, the wire-guiding-roller unit is transferred to a maintenance and running-in station.

Figure 5 shows a suitable maintenance and running-in station 36, in which the wire-guiding-roller unit 6 has been deposited on bearing supports 46. A motor 37 for driving the wire-guiding-roller unit is located in the station. The motor is coupled to the wire-guiding-roller unit by virtue of a linear guide 38 being displaced. The repaired or exchanged bearings 2 and 3 are driven, with the aid of a motor, at certain rotational speeds in accordance with a specified program. During the test run, measurements are taken of the temperatures of the bearings and the vibration caused by the rotating

wire-guiding-roller unit. The test run, which may last several hours, is carried out with the purpose of preparing the wire-guiding-roller unit for use in the wire saw. The intention, in particular, is to bring the
5 wire-guiding-roller unit to a constant operating temperature and to achieve low-vibration rotary movement of the wire-guiding-roller unit. The test run is controlled by a device 41 for monitoring the running-in operation of the wire-guiding-roller unit. In the same way as the
10 fitting station according to Figure 3, the maintenance and running-in station 36 is provided with a heating/cooling system 27 for controlling the temperature of the wire-guiding-roller unit 6. The temperatures of the moveable bearing and fixed bearing are measured by
15 temperature sensors 39 and continuously passed onto the monitoring device 41 via signal lines 40. The signal lines 40 are connected to the temperature sensors via quick-action couplings 42. Once the wire-guiding-roller unit has been installed in the wire saw, it is also
20 possible for the temperature sensors to be connected to a wire-saw control means via the quick-action couplings.

Also connected to the monitoring device 41 are vibration sensors 43, which track the development of vibration during running of the wire-guiding-roller unit.
25 If vibration values which are considered to be permissible are exceeded, the test run is broken off and the wire-guiding-roller unit is balanced.

According to a preferred embodiment, the maintenance and running-in station 36 also has means which can
30 recondition a damaged or worn covering of the wire-guiding roller. These means may comprise, for example, a cylindrical-grinding tool 44 and a groove-grinding tool 45. The cylindrical grinding tool regrinds the covering, and the groove-grinding tool grinds guide grooves in the covering. The drive of the grinding tools is not illus-
35 trated in Figure 5.

Once it has been installed in the wire saw and provided with sawing wire, a wire-guiding-roller unit which has been prepared for use in the maintenance and

running-in station can be used immediately for the purpose of producing wafers. Periods during which the wire saw is at a standstill can be reduced to the time taken to exchange wire-guiding-roller units since, once
5 it has been removed from the wire saw, a wire-guiding-roller unit is immediately replaced by a wire-guiding-roller unit which has been prepared for use in the manner described. In this way, running-in phases in the wire saw and the sawing of test pieces are done away with.



Patent claims:

1. A wire saw for cutting wafers from a workpiece, having a saw head in which at least two wire-guiding rollers are mounted rotatably in each case between a moveable bearing and a fixed bearing, adjacent wire-guiding rollers, together with a wire wound around them, forming a wire frame, wherein each wire-guiding roller and the moveable bearing and fixed bearing assigned to it form a wire-guiding-roller unit, which can only be removed from the saw head as an entire unit.
2. The wire saw as claimed in claim 1, which comprises a removal aid which is provided in the saw head and by means of which the wire-guiding-roller unit can be displaced axially.
3. The wire saw as claimed in claim 1 or claim 2, which comprises temperature-controlling segments for controlling the temperature of the fixed bearing, these segments remaining in the saw head when the wire-guiding-roller unit is removed and automatically coming into contact with a lateral surface of the fixed bearing when the wire-guiding-roller unit is installed in the saw head.
4. The wire saw as claimed in one of claims 1 to 3, wherein the wire-guiding roller and its bearing shafts form a rotating unit which does not have to be separated when the wire-guiding roller is removed from the wire saw.
5. A fitting station for a wire-guiding-roller unit with a wire-guiding roller, a moveable bearing and a fixed bearing, comprising
 - a) supporting surfaces for supporting the wire-guiding-roller unit;
 - b) retaining elements for fixing the wire-guiding-roller unit on the supporting surfaces;
 - c) a heating/cooling system for controlling the temperature of the wire-guiding-roller unit; and
 - d) means for detaching a covering from the wire-guiding roller.



6. The fitting station as claimed in claim 5, wherein the heating/cooling system has means for controlling the temperature of the wire-guiding-roller unit from the inside and of the moveable bearing and of the fixed bearing from the outside.

7. A maintenance and running-in station for a wire-guiding-roller unit with a wire-guiding roller, a moveable bearing and a fixed bearing, comprising
a) bearing supports for supporting the wire-guiding-roller unit;

b) a heating/cooling system for controlling the temperature of the wire-guiding-roller unit;

c) a drive for running in the wire-guiding-roller unit; and

d) a device for monitoring the running-in operation of the wire-guiding-roller unit.

8. The station as claimed in claim 7, wherein the device for monitoring the running-in operation of the wire-guiding-roller unit is provided with sensors which measure the temperature of the bearings and the concentric rotation and vibration of the wire-guiding-roller unit.

9. The station as claimed in claim 7 or 8, which comprises a device for grinding a covering of the wire-guiding rollers cylindrically and for grinding grooves therein.

10. A method of exchanging a wire-guiding-roller unit of a wire saw for cutting wafers from a workpiece, wherein the wire-guiding-roller unit, which comprises a wire-guiding roller provided with a covering as well as a moveable bearing and a fixed bearing, is displaced axially from an operating position into a release position and is removed from the wire saw with the aid of a manipulator, and a wire-guiding-roller unit which has been temperature-controlled in advance is moved into the operating position.

11. The method as claimed in claim 10, wherein the wire-guiding-roller unit which has been removed from the wire saw is provided with a new covering and temperature-



controlled in advance in a fitting station.

12. The method as claimed in claim 10, wherein the bearings of the wire-guiding-roller unit which has been removed from the wire saw are repaired or exchanged, and
5 the wire-guiding-roller unit is transferred into a maintenance and running-in station, in which it is, if appropriate, balanced and checked for concentric rotation, run in and temperature-controlled in advance.

13. The method as claimed in claim 12, wherein the
10 covering of the wire-guiding roller is reconditioned in the maintenance and running-in station.